

Open Theoretical Issues and Solutions for Fusion Relevant Physics Regimes

Major unresolved theoretical issues relating to fusion burning plasmas and relevant new experimental observations have led to the development of a theoretical basis for the following three subjects:

- 1) New detected features of the Quasi Coherent Mode (QCM) in the EDA H-Regime, have led us to formulate a novel theoretical model for which: a) the relevant resistive mode driving factor is the edge sharp plasma pressure gradient; b) a new mode topology is identified, as the “disconnected mode approximation” cannot be applied given that the rotational transform $\iota(\psi) \equiv 1/q(\psi) = 0$ on the Last Closed Magnetic Surface (LCMS) around which the mode is localized radially; c) the mode localization in the poloidal direction (ballooning) is related to the limited region around the equatorial plane where the pitch of the magnetic field is about constant.
- 2) Modes producing reconnection in low collisionality regimes have been observed to have a phase velocity in the direction of the ion diamagnetic velocity while the well-accepted high temperature, resistive drift-tearing mode theory predicted only modes with opposite direction of their phase velocity. To explain the observations, a “mode inductivity” that can represent the electromagnetic coupling of the current channels inside the reconnection layer with others outside it is introduced. This leads to find a dissipative instability with a phase velocity slightly below the relevant ion diamagnetic velocity. On the other hand, a mode with a phase velocity in the direction of the electron diamagnetic velocity can emerge when a finite plasma resistivity is considered.
- 3) The observed (radial) velocity profiles of the “spontaneous rotation” in axisymmetric plasmas are consistent with the transport equation for the angular momentum that is not, in general, of the diffusive type. Accordingly, a theoretical model is introduced to identify the modes capable of producing an angular momentum “inflow”, opposite to the direction of diffusion flow. The electrostatic resistivity gradient (ERG) driven modes and the tri-dimensional heating modes, which are considered, involve significant electron temperature fluctuations as indicated by experiments in which the spontaneous rotation velocity profiles are peaked and the inflow term is needed in the transport equation to reproduce the profiles.